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PRESENTATION

to

THE CORPORATION OF THE CITY OF HAMILTON

POLLUTION CONTROL COMMITTEE

by

THE STEEL COMPANY OF CANADA, LIMITED

Tuesday, August 14, 1973

stelco

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Lockwood Survey Corporation Limited

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Mr. Chairman and Members of the Pollution Control Committee:

We welcome this opportunity of meeting with you again in order to discuss some of the details of our environmental quality control program.

Prior to our last meeting with you on May 31, 1973, we were unable to anticipate the questions that you might raise and therefore we were not as well prepared as we should have been. This is the reason why we asked for written questions in order that we could prepare a submission which we think will be satisfactory to you and which will answer your questions.

After reviewing the questions which were submitted to us we concluded that many of them were interrelated and for the sake of simplicity, we have sorted them into three general categories which will form the basis of our presentation. These categories are particulate emissions, SO_2 emissions, and fluoride emissions.

As far as the format of our meeting is concerned, I would like to make a few general comments and then call upon Mr. A. C. Elliott, Stelco's Superintendent of Utilities, and Mr. M. J. d'Andrade, Senior Engineering Supervisor, who have been deeply involved in these matters to make a presentation to you. If you have any questions at the conclusion of our presentation, we will be pleased to answer them for you.

With respect to atmospheric emissions, it has been estimated that of the several hundred million tons of pollutants that are emitted into the air annually, roughly 25% comes from industrial sources. An equal amount is contributed by household chimneys, apartment complexes, commercial buildings, municipal incinerators and power plants. The remaining 50% emanates from a variety of internal combustion engines in various areas of use. I make this point, not as a means of absolving industry of its share of responsibility, but rather to help put the problem into appropriate perspective by indicating that it is society-wide in nature.

The principal thrust of our air quality program has been in the direction of particulate matter emission, which has engendered the greatest degree of community concern, primarily because it is obvious. By 1975, we expect to have achieved a better than 90% cutback in particulate matter emissions from Hilton Works. As far as fluorides are concerned, we fully expect that emissions will soon be well within the criteria established by the Province of Ontario. As well, by 1975 we will have an effective technology for the control of sulphur dioxide emissions. Mr. Elliott will have more to say on these matters later.

I think it would also be of interest to point out at this time that Stelco has been a pioneer in many areas of pollution abatement technology. Not only were we the first steelmaker in North America to collect, clean and recycle blast furnace gas - and this accomplishment goes back to 1928 - but we were also the first Canadian steelmaker to put engineers and technicians to work on a full-time basis on environmental quality control problems. In addition, we were the first North American steel producer to utilize a smokeless coal charging car in our cokemaking operations and we are also a world pioneer in the use of wet tubular precipitators to control particulate matter emissions from scarfing operations. I have outlined these accomplishments to illustrate that we employ our technical expertise not only to increase production, but also to find solutions to problems inherent in environmental quality control.

As far as financial expenditures are concerned, we have spent or committed since 1960, something in excess of $64 million on our environmental quality control program.

By 1975, we expect that this expenditure will have risen to more than $85 million.

I have made these general comments to re-emphasize the fact that we at Stelco are not only aware of your concern but we have also been fully aware of our responsibilities at all times and use every means at our disposal to attempt to correct environmental problems which arise.

I will now call upon Mr. Elliott to present our submission.

Gentlemen:

For the sake of clarity, the submission will deal with three main topics in the following sequence:

1. Particulate emissions
2. SO_2 emissions
3. Fluoride emissions

Particulate Emissions

In the operation of an integrated steel plant, there are numerous potential sources of atmospheric particulate emissions. From the outset, The Steel Company of Canada, Limited recognized that its abatement priorities had to be directed towards a reduction of these emissions. Accordingly, we are pleased to report what has been achieved to date and outline what remains to be done.

Table I is a general outline of the principle potential sources of particulate emissions and the present rate of emissions.

PRINCIPLE DUST SOURCES — TABLE I

SOURCE	DUST PRODUCED T/D	DUST COLLECTED T/D	COLLECTORS USED	DUST EMITTED T/D
Coke Ovens	8.79	2.25	Scrubber Double Collector Main	6.54
Sinter Plant				
a) Sinter Strand	33.6	30.0	Mechanical	3.60
b) Strand Discharge	14.0	13.99	Cloth filter	0.012
c) Screening	21.0	20.94	Scrubber	0.06
Blast Furnaces	210.0	209.75	Mechanical Scrubber Precipitators	0.25
Cast Houses	1.6	-	-	1.60
Open Hearth				
a) Furnaces	225.0	217.67	Precipitators	7.33
b) Roof Monitors	1.63	-	-	1.63
B.O.F.				
a) Furnaces	135.0	126.35	Precipitators	8.65
b) Roof Monitors	3.3	-	-	3.30 (calculated)
Scarfers	16.0	15.44	Precipitators	0.56
Acid Regeneration Plant	32.00	31.90	Precipitators Cloth Filters Scrubbers	0.10
TOTAL	701.92	668.28		33.53
TOTAL % COLLECTED		95.2		

FUTURE EMISSION REDUCTIONS
(Using Table I)

TABLE II

SOURCE	REDUCTION TONS/DAY
Coke Ovens	5.21
Sinter Plant	3.40
O.H. Furnaces	2.33
B.O.F. Furnaces	7.21
Net Reduction	18.12
Total Dust Produced	701.92
Total Dust Collected	686.40
Dust Emitted	15.41
TOTAL % COLLECTED	97.8

COAL AND ORE STORAGE AREA

The movement and storage of large quantities of raw materials required for steelmaking is a serious potential source of fugitive emissions. Wind erosion of stockpiles and dust clouds rising from the travelled portion of the storage area were prevalent during extended periods of dry weather. As a remedial measure, The Steel Company of Canada, Limited purchased a powerful water spray truck capable of pumping 10,000 gallons of water in 15 minutes. Consequently, problem areas are now sprayed as required.

We have also made it mandatory that all self-unloading ore and coal carrying vessels using our facilities be equipped with water spray systems on their conveyor belts to minimize dust conditions.

The practice of spraying roadways has been extended throughout Hilton Works to further reduce such emissions.

SINTER PLANT

The Sinter Plant provides the only practical outlet for the disposal of a substantial tonnage of coke and metallurgical fines -- fine iron oxide particles -- produced and recovered in the various processes throughout Hilton Works.

There are three separate dust collecting systems in the Sinter Plant. The first is associated with the products of combustion discharged from the main sinter strand. The gases drawn through the sinter bed entrain a considerable amount of dust. The gases first pass through sixteen parallel settling chambers. Since the physical characteristics of the dust vary along the strand, two types of chambers are provided. Those at the entry and discharge ends of the strand contain concentric tubes to intercept the finer particles while the middle eight chambers are simply baffled to precipitate the coarser particles. The hot gases are subsequently pulled through another mechanical collector before being exhausted to atmosphere. This equipment reduces the dust loading in the waste gases from an equivalent emission rate of 33.6 tons per day down to 3.6 tons per day.

To further reduce these emissions, we have recently completed a field evaluation of the parameters affecting the design of additional abatement equipment. An engineering evaluation of the field test data obtained is under way. Later this year we expect to make a commitment to the Ontario Ministry of the Environment as to the equipment proposed to further reduce these emissions.

Since the sintering process is essentially a scavenger operation, we are compelled to take a cautious approach in the provision of abatement facilities. Every sintering installation is faced with different problems, depending on the mix of feed material. Problems have been encountered with both dry and wet collectors at other installations. The variety of equipment used by the steel industry illustrates the complexity of the problem. The following has been installed or is being considered:

Wet and dry electrostatic precipitators

Low and high energy scrubbers

Combinations of scrubbers and precipitators

and finally,

Fabric filters

The other two dust collecting systems in the sinter plant handle dust-laden air vented from the sinter crushing and screening operation and from numerous conveyor points. Until recently, mechanical and wet collectors were used on these systems. In order to upgrade the performance of the mechanical collectors, we recently added a fabric filter to the system.

COKE OVENS

Atmospheric emissions from Coke Ovens occur principally during the charging of coal to the oven. To a lesser degree, emissions are also visible during the pushing of coke from the oven and from oven door leakages.

Our first attempt to control emissions during coal charging was a scrubber mounted on the charging car. We experienced numerous problems with the operation of this equipment, such as minor explosions, poor combustion of the gases, freezeups, etc. Most of these problems have been resolved, but the performance of this equipment is still marginal.

Our second attempt consisted of engineering a coal-charging car that sealed the oven during charging. This approach has proven very satisfactory.

This equipment was installed during the construction of a new coke oven battery. However, it is not possible to duplicate it on existing batteries since double gas collector mains are required and existing batteries are equipped with single mains only. We are now experimenting with an alternative system for the older batteries, whereby interconnections between adjacent ovens are being made to improve the suction during coal charging.

Our Board of Directors recently approved the purchase of one new coal-charging car for #6 battery. The main features of this type of car are single spot lidding and sequential coal charging. As previously mentioned, modifications will also have to be made to the battery before the car becomes operational. We expect this project to be completed by January, 1975.

Depending on the operating results obtained from this experimental equipment, a decision will then be made to proceed with similar equipment for older Wilputte batteries. The decision, however, will be tempered by a number of factors, such as the age and the physical conditions of the batteries. We may find it advantageous to shut down older batteries rather than incur heavy modification expenditures. We could expect to have the third pollution-free coal-charging car in operation by December, 1977. Assuming that one battery could be permanently removed from service by then or in the immediate future, we would have adequately controlled coal-charging capacity.

The level of emissions during coke pushing is dependent on the content of volatile constituents remaining in the coke. To insure complete carbonization of the coal and thus minimize emissions, we provided an additional 29 ovens in conjunction with a new battery. This enable us to extend the coking period on existing ovens to cycles considered adequate to ensure proper coking.

To further reduce emissions during pushing, we are now investigating the possibility of providing additional control equipment. Assuming that the engineering and technological problems can be resolved, we could expect a prototype unit to be operating by late 1975 and, if successful, similar units provided subsequently.

The Steel Company of Canada, Limited has a total of four coke-quenching stations in operation at the present time. All have been equipped with baffle plates and demisters to reduce particulate emissions during the quenching operation. In one instance, it was necessary to completely rebuild a tower to provide the necessary structural support for the spray and baffle equipment.

We find the equipment provided very effective for particulate and vapour removal. The precipitation of the dust particles is enhanced by the presence of water droplets formed by the condensing water vapours impinging upon the baffles. At regular intervals, water sprays are activated to clean the baffles.

BLAST FURNACE

The Blast Furnace process is a closed system and under normal operating conditions, blast furnace gas does not escape to atmosphere. In this process, the heated air blown upward through the porous burden is altered by chemical reactions to form a useful by-product fuel. Before distribution of the blast furnace gas, the ore fines and other entrained contaminants must be removed to a very high degree of efficiency. This is achieved by installing three categories of collectors in series.

Incidentally, The Steel Company of Canada, Limited was the first steelmaker in North America to clean blast furnace gas and distribute it as a by-product fuel.

The gas is first passed through a giant mechanical collector removing approximately 60% of the dust from the gas. The accumulated dust is periodically trucked to the Sinter Plant for reprocessing. The gas is then scrubbed by a Venturi-type washer mounted within the duct conveying the gas. Upstream from the Venturi constriction, an annular spray system creates an intense water curtain. The dust particles impinge on the water droplets to form a weak slurry. The efficiency of the washer is enhanced by the high velocity and the turbulent flow pattern caused by the restriction. The gas is given a final cleaning in a wet-wall tubular-type precipitator to remove the extremely fine particles.

The clean blast furnace gas distributed contains less than 0.005 grains per standard cu. ft. of particulate matter.

Blast furnace cast houses are sources of intermittent visible emissions. Studies carried out by The Steel Company of Canada, Limited personnel, the Ontario Research Foundation and other consultants, indicate that emissions from cast houses are low and average 0.4 tons per day per cast house. The mean particulate concentration in the air during the casting operation is 0.048 gr./cu. ft. Since the particles escaping to atmosphere are relatively coarse and the exit velocity is low, the carryover beyond our property line should also be low. Consequently, even if these sources could be practically controlled, we doubt if any detectable reductions in dust fall could be measured.

Engineering estimates show that to completely enclose a cast house and provide for total air evacuation would require 800,000 cfm or 3.2 million cfm to control four cast houses at an estimated cost of 15 million dollars. The capital cost per ton of dust collected per day becomes an astronomical 9.6 million dollars. The capital cost of collecting a ton of dust per day up to 1970 was $22,400. The large disparity is due mainly to the large volumes of air that must be handled and the minute quantities of dust collected.

Certainly, we as company managers have a responsibility to ensure that expenditures of economic resources of this magnitude show a clear benefit to society. We also believe that you are faced constantly with the same type of cost-benefit decisions and as responsible elected representatives and citizens understand the problem.

Another important factor to be considered in the assessment of environment problems is the total impact abatement projects may have on our resources. Our decisions should not be influenced by parochial attitudes but guided by our national goals. As an illustration, to exhaust 3.2 million cfm of air at 10" W.C. will require 7,200 H.P. or 5,360 K.W. To generate this power would consume 1250 gallons of oil/day and exhausts to atmosphere 1.2 tons of SO_2. We are therefore trading, at great economic cost, 1.6 tons of particulate for 1.2 tons of SO_2, and in the process, consuming disproportionate energy resources that are now in increasingly short supply.

We are, however, continuing our efforts to minimize these emissions whenever possible. In recent years, we have completely abandoned the oxygen lancing of tap holes, which was a principle source of fume emissions. We are also experimenting with substitute materials to be used in the hot metal runners to reduce the evolution of fumes.

We are of the opinion that with the successful implementation of practical in-process changes, blast furnace cast house emissions could be kept to acceptable levels.

OPEN HEARTH

Metallurgical fume emissions from oxygen-lanced steelmaking facilities represent the industry's most serious potential source of particulate emissions. With the introduction of the oxygen-lancing practice in our #3 O.H. Shop, The Steel Company of Canada, Limited initiated an effective abatement programme with the installation of electrostatic precipitators. When #16 Furnace in #2 O.H. Shop was converted to oxygen lancing, it was similarly connected to the precipitator installation.

In 1972, we completed the shutdown of the non-oxygen-lanced furnaces at #2 O.H. Shop. Although these units could have maintained production for a number of years, we could not economically justify the large expenditures required to provide them with the necessary collectors.

In the near future, we are planning the shutdown of #16 Furnace. The result of this shutdown will be a reduction in the loading on our precipitator installations, which are operating at peak capacity. At that time, emissions will be reduced by 2.33 tons/day to a level of 5.01 tons per day. It should be noted that these emission rates represent visibly clean stack conditions.

Our reasons for proceeding with the installation of dry electrostatic precipitators for this application have been documented and presented to this committee on a previous occasion.

The transfer of hot metal from the blast furnace ladle cars to the Open Hearth ladles gives rise to graphite and iron oxide fume emissions. Several years ago, we installed a mechanical collector pilot plant to obtain the necessary data to design a full-scale unit. Despite our deliberate approach, we discovered that the full-scale equipment did not perform as expected. To control emissions from the second hot metal transfer station, we installed a fabric filter. The results obtained from this type of equipment have been satisfactory. Consequently, we will replace the original equipment installed on the first hot metal station with the proven equipment.

OPEN HEARTH ROOF MONITORS

Activities within the Open Hearth Shop such as hot metal additions, tapping, furnace reversals, etc., generate fumes that rise to the roof monitors and escape to atmosphere.

Roof monitors are therefore periodically a source of visible emissions. In this instance, we face the same economic and technical dilemma as in dealing with blast furnace cast house emissions. Very large volumes of air would have to be handled to remove relatively small quantities of particulates. While the problem has not as yet been defined, it has been estimated that a minimum of 4.4 million cu. ft. of air would be cleaned at a capital cost of $25,000,000. Emissions have been measured at 1.63 tons per day.

The Ontario Research Foundation is conducting field tests to determine more accurately the air volume, velocity, distribution, and finally, the contaminant concentration of the air emanating from this large building.

It is hoped that new technological developments will enable us to reduce these emissions without having to resort to the unacceptable alternative of total shop evacuation. While such an approach would prove effective in reducing emissions, we feel that the cost would be prohibitive. We know of no other steelmaker anywhere who has adopted or is considering total evacuation of an Open Hearth Shop.

We again reiterate our concern for the disproportionate cost-benefit ratio , the power requirements and the total environmental impact of such a project.

B.O.F. SHOP

The Steel Company of Canada, Limited's newest steelmaking shop has seven separate dust-collecting systems, built at a cost totalling 15.5% of the project. Included are five fabric filter installations, one mechanical collector and one electrostatic precipitator system. A number of modifications and additions were made to this equipment after start-up to improve collection efficiency. The latest improvement under construction consists of three additional electrostatic precipitators to relieve the operating load on the six units originally installed. The only outstanding project to be completed is the building of retaining baffles on two vessels to trap the fumes during the pouring operation. One vessel has been so equipped and we are satisfied with the operating results. When this work is completed and the additional precipitators started up, we are confident that this steelmaking shop will compare most favourably with other similar installations with respect to total fume emissions.

We shall then have provided particulate collectors for the hot metal transfer station, the charging and pouring sides of the vessel, the vessel itself, and numerous material handling locations.

We estimate that the precipitators will be discharging to atmosphere 1.44 tons per day under clean stack conditions and that emissions from fugitive sources within the shop will be an estimated 3.3 tons per day.

SCARFER OPERATIONS

In order to produce a high quality steel product, surface imperfections must be removed by a process called scarfing.

Because of the high temperatures generated during the scarfing operation, some of the steel being removed from bloom and billets is vapourized and subsequently oxidized. A considerable amount of cooling water is also evaporated. It is necessary to exhaust the iron oxide fume and water vapour from the vicinity of the scarfing machine to ensure adequate visibility and working conditions for mill personnel. The exhausted fume is extremely fine and even though the concentrations are relatively low, a highly visible reddish plume results.

Before committing itself to a choice of equipment, The Steel Company of Canada, Limited investigated the collecting equipment used elsewhere for similar applications. In most instances, some operating difficulties or design inadequacies were encountered. To avoid similar pitfalls, we decided to pursue a totally new concept.

The equipment selected was a tubular-type wet electrostatic precipitator. Since the gases entering the precipitator are saturated with water vapour, it was felt that the collected material could be more readily removed by water sprays than by mechanical shakers. Our operating experience with this equipment has been very satisfactory.

To our knowledge, this was the first installation of its type anywhere. All scarfer installations in Canada have since been similarly equipped and a number of American companies are following our lead.

COMBUSTION PROCESSES

In the making of iron in the refinement and shaping of steel, large quantities of energy are required. These requirements are met by the combustion of coal, in the form of coke in the blast furnaces, and by the burning of liquid and gaseous fuels in other furnaces. As previously discussed, the blast furnace is a closed system and the blast furnace gas distributed as a by-product fuel. In the operation of heating and reheating furnaces, emissions are restricted to the normal products of combustion.

Black smoke from furnace stacks is rare today. To achieve this, we maintain a large staff of instrument and combustion specialists. Their total understanding of furnace technology, combustion techniques and sophisticated instrument controls maintain our combustion processes at peak efficiencies and ensure proper combustion.

MISCELLANEOUS

There are a number of other minor sources throughout Hilton Works that have required remedial measures. In specific instances, substantial expenditures have been incurred to control these sources. Included in this list are precipitators for the hydrochloric acid regeneration plant, fabric filters and mechanical collectors for grinders, miscellaneous collectors on coal-handling systems, improved dust-handling and storage facilities for acid regenerator dust, etc.

We would like to conclude our remarks on particulate emissions with the following observations:

There has been a tendency to equate the dustfall readings taken by The Ministry of the Environment directly with The Steel Company of Canada, Limited. However, a comparison of the ambient dustfall and ambient iron oxide readings suggests that the dustfall in the worst areas is only 12% iron oxide. Since The Steel Company of Canada, Limited's process emissions are calculated to be 70% iron oxide, one could conclude that they represent a small proportion of the total dustfall.

The Steel Company of Canada, Limited consumes 115 million BTU's per minute of energy in its various steelmaking processes. Twenty million BTU/min. are rejected as sensible heat to surrounding air. Since hot air rises, the rejected sensible heat sets in motion 91.6 million cubic feet of air and waste gases per minute over the entire plant.

Process stacks emit 13.2 million cubic feet of waste gases per minute so that the air mass set in motion is about 68.4 million cubic feet. Ground dust stirred up by winds results in a dust concentration of about 0.01 grains/cubic foot, so that the dust airborne by this micrometeorological phenomenon is about 68.4 tons per day. This represents the uncontrollable base particulate load in the air over Hilton Works.

This completes our review of the sources of particulate emissions at Hilton Works.

SO_2 EMISSIONS

While we fully intend to comply with the Ministry of the Environment's request to reduce SO_2 emissions, it should be noted that during 1972 the ambient sulphur dioxide levels at the Barton and Wentworth monitoring station were within the standard promulgated by the province. Also, while the sulphation rates within the city's industrial zone do exceed the provincial limits, we are of the opinion that the level of sulphation rates does not justify the implementation of hasty and perhaps ill-conceived remedial measures.

Based on the analyses and quantities of fuel consumed, we calculate our SO_2 emissions from Hilton Works to be 50.8 tons per day. The following is a breakdown of the sources of sulphur:

Low sulphur oil (0.93% S)	10.3 tons
High sulphur oil (2.0% S)	6.5 tons
Coke Oven Gas	33.0 tons
Sinter Plant	1.0 tons
Total	50.8 tons

As indicated by the table, the only practical approach to reduce SO_2 emissions is the removal of hydrogen sulphide from the coke oven gas. To this end, a task force has been formed to evaluate the various processes proposed to achieve desulphurization of the coke oven gas.

The prime consideration is to avoid converting an air pollution problem into one of water or solid waste disposal. A suitable disposal method for the recovered sulphur is a prerequisite for any selected process.

It is hoped that the field and technological studies, including plant visits on this continent and abroad, will be completed by the end of this year. Subsequently, we expect to be in a position to make a commitment to the Ministry of the Environment with respect to the type of process selected and discuss a project completion date.

A reduction of 3.0 tons per day in sulphur dioxide emissions could also be realized if a complete switch from high to low sulphur fuel oil were made. However, we fear that low sulphur fuel oil will be in very short supply for a number of years to come. There has been a virtual stagnation in the growth of petroleum refineries in the United States in relation to the demand for petroleum products. Also, in recent years, American refineries have maximized high octane gasoline and distillate production to the detriment of residual fuel oil production.

With the knowledge that it takes at least 2.5 years or longer to complete a refinery from contract to start-up, virtually nothing in terms of new capacity for low sulphur fuel oil could be realized until sometime in 1976. Shortages on the American market will certainly reflect similar conditions in Canada, making the availability of low sulphur fuel oil very uncertain.

The practical technology to remove sulphur dioxide from stack gases has not as yet been developed, although considerable research is being carried out in this field. We doubt, however, that this approach would ever prove feasible in our operations due to the large number of small heating processes that would require attention.

FLUORIDES

Sources of emission of fluorides in Hilton Works are:

1. The Open Hearth Furnaces
2. The Basic Oxygen Furnaces
3. The Sinter Plant

THE OPEN HEARTH FURNACES

At Hilton Works, The Steel Company of Canada, Limited operates four 300-ton Open Hearth Furnaces and one 500-ton furnace in #3 Open Hearth Shop and one 180-ton furnace in #2 Open Hearth Shop.

These units refine a charge of steel scrap and molten basic iron to produce a steel of required specification.

The tap to tap time of these furnaces is about four hours. During this period, the scrap charge is melted, basic iron added, and the carbon content of the melt reduced by blowing with oxygen. Impurities in the melt such as silicon, phosphorous and sulphur are oxidized and removed from the melt by solution in a basic slag formed by the addition of dolomitic lime.

The liquid slag layer formed above the molten steel consists of a solution of Silica (SiO_2), Ferrous Oxide (FeO) and Lime ($CaO + SiO_2$). As the refining process proceeds, the ferrous oxide content of the slag decreases and the lime content increases until the lime saturation point is reached.

These changes in slag composition result in a decrease in slag fluidity and a resulting decrease in physio-chemical activity in the slag. The slag fluidity is increased by the addition of Fluorspar (CaF_2).

The quantity of spar added is between 4 and 12 lbs. per ingot ton of steel. At Stelco the additions of spar have been gradually reduced and kept to a minimum, so that present open hearth practice uses about 5 lbs. per ingot ton of steel.

The largest open hearth furnace uses about 2,500 lbs. of spar per heat. The rates and duration of fluoride emissions vary drastically from heat to heat but on the average about 11% of the fluoride in the spar is emitted in the stack gases. Of these emitted fluorides, about 95% is in the gaseous form. When reported as Hydrogen Fluoride (HF), the concentration of fluorides in the stack gases averages about 67 parts per million from charge to tap. From scrap charge to spar addition, the concentration of fluorides in the stack averages about 14 P.P.M. From spar to tap, it averages 167 P.P.M. Peak levels of up to 500 P.P.M. occur immediately after spar addition. The calculated maximum half-hour average ground level concentration is about 74 ppb, which exceeds the maximum allowable half-hour level of 5 parts per billion.

In the slag, calcium fluoride and calcium silicate react to form calcium oxide and gaseous silicon tetrafluoride.

$$CaF_2 + \tfrac{1}{2}\, CaSiO_3 \rightleftharpoons \tfrac{3}{2}\, CaO + \tfrac{1}{2}\, SiF_{4(g)}$$

This reaction is reversible and the quantity of silicon tetrafluoride (SiF_4) formed is determined by the equilibrium constant, K_p, for the reaction which is a function of temperature.

At Open Hearth slag temperatures (2990°F), the equilibrium constant, K_p, for this reaction is 0.00011, and,

$$p(SiF_4) = 1.21 \times 10^{-8} \left[\frac{[CaF_2] \quad [CaSiO_3]^{1/2}}{[CaO]^{3/2}} \right]^2$$

A silicon tetrafluoride (SiF_4) concentration of about 0.003 parts per million of waste gases will occur if the time is long enough for the reaction to proceed to equilibrium. Since the Open Hearth refining process is comparatively long, it is probable that equilibrium will be reached.

This reaction obviously produces very little gaseous fluorides. However, in an Open Hearth furnace, there is also present considerable amounts of water vapour in the waste gases over the bath and in contact with the hot slag in the slag pockets. This water vapour is produced by the combustion of the hydrogen in the fuel, by the atomizing steam in the burners, and by the cooling sprays in the slag pockets and regenerator inlets.

The water vapour reacts with silicon tetrafluoride (SiF_4) and calcium fluoride (CaF_4) to produce silica, (SiO_2), Lime (CaO) and gaseous hydrogen fluoride (HF).

$$SiF_4\ (g) + H_2O(g) \qquad SiO_2 + 4HF_{(g)}$$

$$CaF_2 + H_2O_g \qquad CaO + sHF_{(g)}$$

Since silicon tetrafluoride formed is negligible, very little hydrogen fluoride is produced from this source. The equilibrium constant for the formation of hydrogen fluoride from calcium fluoride is 0.023 at 2990°F.

and:

$$p(HF) = 1.52 \times 10^{-1} \left[\frac{(CaF_2)\ P(H_2O)}{(CaO)} \right]^{1/2}$$

Since the waste gases may contain up to 10% moisture the resulting concentration of HF in the waste gases is about 2.4%. Of course, not all of the HF escapes in the stack gases. Some of it is absorbed by the furnace brickwork and some of it reacts with lime dust present in the flues at lower temperatures.

It is evident therefore that favourable conditions with regard to chemistry and time exist for the formation of Hydrogen Fluoride in an Open Hearth furnace.

The elimination of HF in the stack gases of an open hearth furnace may be achieved by:

1. Scrubbing the gases with fluoride-free water. (i.e. no recirculation)
2. Scrubbing with a lime slurry
3. Reacting with lime and collecting the calcium fluoride (CaF_2) formed
4. Elimination of fluorspar additions

Because of process requirements, higher reliability, and superior performance on submicron dusts, Stelco's Open Hearth furnaces are equipped with dry electrostatic precipitators for removal of particulate matter from the stack gases.

The use of scrubbers following the precipitators was considered for the removal of gaseous fluorides. The solution was rejected because:

1. The problems of cleaning large quantities of water having very low fluoride concentrations
2. The production of a low buoyancy stack plume saturated with water vapour which would be a potential hazard due to fogging and icing

Removal of the hydrogen fluoride by injection of lime dust into the flues was also tried but this was unsuccessful due to the small residence time and the large excess of lime required.

At present, Stelco is completing a research programme in which fluorspar will be replaced by other slag conditioning agents.

Of the various substitutes investigated, three were found to be a suitable replacement for fluorspar. These are:

1. Manganese Ore
2. Colemanite
3. Ilmenite

Successful plant scale tests have been carried out with Colemanite and tests with Ilmenite and Manganese Ore are now under way.

During the Colemanite test, stack gas analyses indicated that about 2% of the Boron in the Colemanite was emitted in the stack gases. The concentrations of Boron in the stack gases ranged from about 3.5 to 8.5 ppm with a mean value of 6.3 ppm. The maximum ground level concentration was computed to be 0.0007 ppm.

As yet, there is no standard for Boron or Boron compounds in the Ontario regulations, but the Threshold Limit Value (T.L.V.) of Boron Oxide (B_2O_3) 10 mg/m^3 or expressed as Boron, 12 ppm.

The Boron compound present in the stack gases is probably Boron Oxide (B_2O_3) and exists as a very fine particulate less than 0.1 micron.

THE BASIC OXYGEN FURNACE

Stelco operates three 120-ton Basic Oxygen furnaces. At any time two units are operational and one is on standby. In these vessels, molten basic iron is refined to give steel of a required analysis by blowing gaseous oxygen onto the surface of the melt. Steel scrap and iron ore are introduced into the vessel as coolants and the impurities, such as silicon, phosphorous and sulphur are oxidized and removed by the addition of lime to form a slag. The conversion process is very rapid so that the refining time is only about 20 minutes and the tap-to-tap time about 40 minutes.

As in the Open Hearth, as the refining proceeds, the slag fluidity decreases and fluorspar is added to maintain a fluid slag.

The fluorspar additions in the B.O.F. are much larger than in the Open Hearth. About 10-35 lbs. spar per ingot ton of steel are used. At the present time, the use of spar in Stelco's B.O.F.'s has been reduced to less than 13 lbs. per ingot ton of steel.

Despite the higher use of spar (13 vs 5 lbs.) in the B.O.F., the fluorides emitted in the stack gas are reported to be only about 1/5 that of the Open Hearth.

The significant difference in fluoride emissions in these two processes is due mainly to the absence of water vapour in the gases in contact with the slag.

The gases evolved from the bath reaction are CO and CO_2 and under these conditions a gaseous fluoride can only be formed by the reaction of calcium fluoride (CaF_2) with calcium silicate ($CaSiO_3$) to produce calcium oxide (CaO) and silicon tetrafluoride (SiF_4).

$$CaF_2 + 1/2\ CaSiO_3 \rightleftharpoons \frac{3}{2}\ CaO + 1/2\ SiF_4(g)$$

For this reaction, the equilibrium constant at 2990°F is 0.00011, so that at equilibrium the silicon tetrafluoride (SiF_4) concentration in the waste gas is only about 3 ppb. Further up in the waste gas hood, the silicon tetrafluoride may be converted into hydrogen fluoride (HF) when the gas is cooled with water sparys. However, due to the small concentration of silicon tetrafluoride and the low residence time, very little hydrogen fluoride is formed.

In practice, stack measurements indicate that the fluoride concentration in the stack gases is between 3.2 and 4.9 ppm, of which about 80-85% is gaseous fluorides. The maximum calculated ground level concentration from the B.O.F. stacks was found to be 1.7 ppb. The current regulations permit 5 ppb average over one-half hour.

THE SINTER PLANT

Stelco operates one 2400-ton per day sinter plant at Hilton Works. The operation is essentially a recycle operation. Dust and filter cake removed from the Blast Furnace gas cleaning system along with mill scale recovered from the waste water in the mills are agglomerated, fluxed and converted into iron units suitable for conversion to basic iron in the blast furnaces.

The stack gases from the sinter plant contain between 10 and 30 ppm of fluorides. At the present time, investigative work and preliminary design work is under way to install pollution abatement equipment on the Sinter Plant main stack. Since a combination scrubber and wet electrostatic precipitator is proposed, the fluorides, oil mist and particulates will be effectively removed from the stack gases.

AMBIENT GASEOUS FLUORIDE LEVELS AT STELCO

In July, 1971 with #2 Open Hearth Shop operating and the B.O.F. not yet operating, ambient measurements of gaseous fluorides were carried out at Stelco. These measurements, taken about one-half mile on either side of the open hearth furnaces, indicated that highest levels were measured for westerly winds (48% of winds from W to S.W.). For 372 analyses, the average fluoride levels were 1.9 ppb.

The highest single result was 30 ppb, which compares with the computed stack value of 74 ppb, which assumes worst possible wind conditions at time of maximum emission.

The maximum half hour limit of 5.0 ppb was exceeded for only 3.7% of the time. The overall arithmetic average for the test period was 0.8 ppb which exceeded the limit set by the desirable ambient air quality of 0.5 ppb average over 30 days.

Since these tests were made, Stelco has shut down eight furnaces in #2 Open Hearth Shop whose waste gases contained between 40 and 300 ppm fluoride with an average value of 92 ppm.

These were replaced by the B.O.F.'s having approximately the same volume of waste gases but containing only an average of about 4 ppm fluorides.

Mr. Chairman, Members of the Committee:

This concludes our formal submission and we trust that it has answered satisfactorily the questions you have raised. We have attempted as far as is possible to provide you with a detailed outline of what we have accomplished to date through our air quality control program, some of the problems we are currently facing and what we expect to achieve in the future.

I would like to re-iterate once more the degree to which our Company is committed toward playing its part in upgrading the quality of our environment. In this endeavour, we are proceeding and will continue to proceed as fast as technology and resources will allow.

If you have any questions relating to our submission, we will be happy to answer these to the best of our ability.

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